Deep Learning Application for Community Machine Learning

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Outline

- Introduction
- Research
  1. Detection and Localization of Extreme Climate Events
  2. Increase localization accuracy using Pixel Recursive Super Resolution
  3. Tracking Extreme Climate Events
- Future Works

Introduction

- **Deep Learning for Climate Data**
  - Deep Learning:
    - Capture the non-linear, underline pattern in massive scaled Data
    - Successful in computer vision, NLP
  - Pattern Analysis for massive scaled Climate Data:
    - Climate Object Detection → object detection in Vision
    - Time series analysis (tracking, forecast) → language translation in NLP
- **Deep Learning for ESGF**
  - Only way to analyze Peta-scaled data in ESGF
  - Save human effort and computing power for data analysis
  - Distribute labeled dataset for climate informatics community

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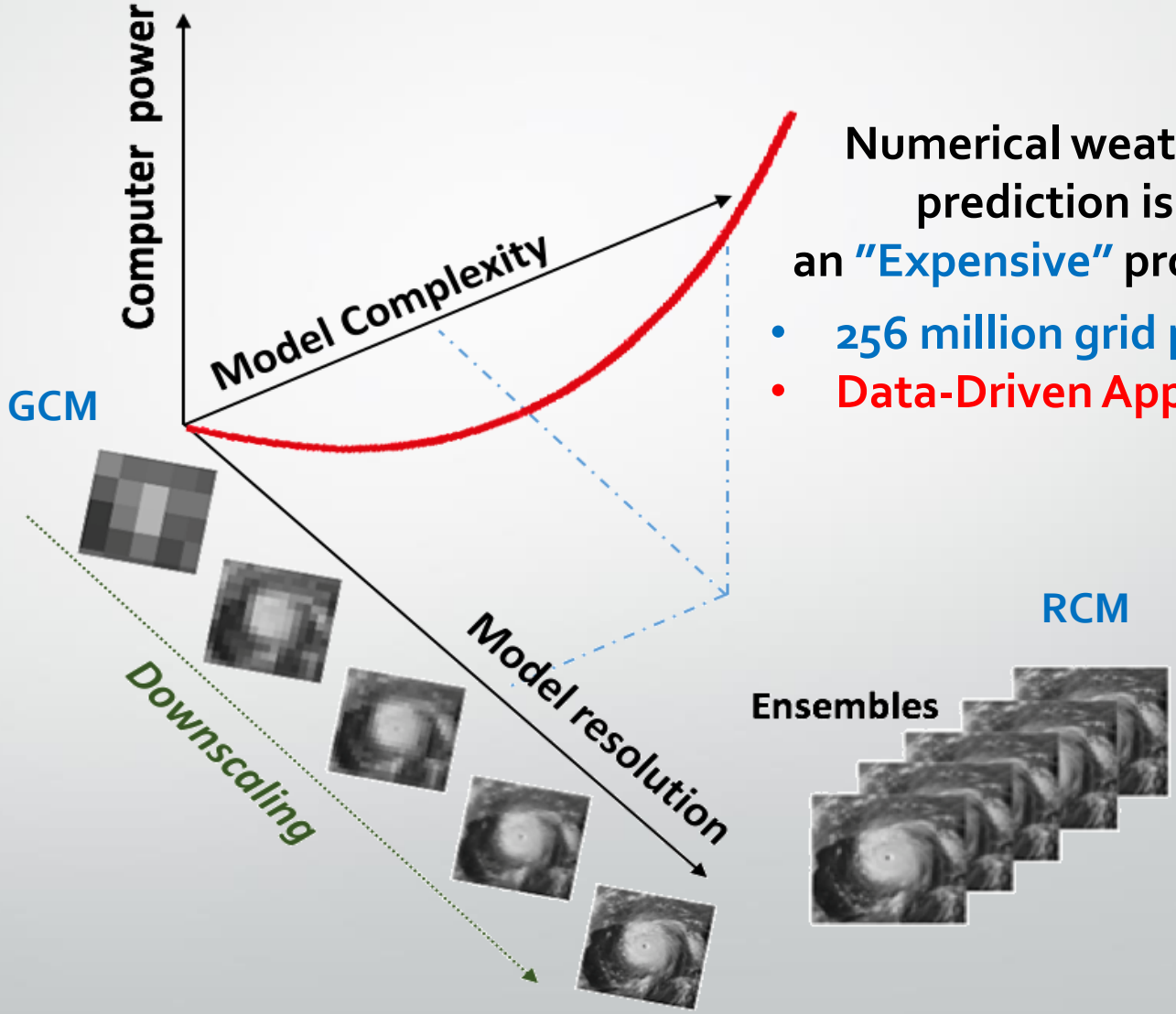
1. Detection and Localization

(1) Motivation

- Let CNNs **learn feature** representation of extreme climate events **in GCM outputs**
- Ultimately **save computing cost** for Numerical Weather Predictions



Numerical weather prediction is an "Expensive" process!

- 256 million grid points
- Data-Driven Approach?

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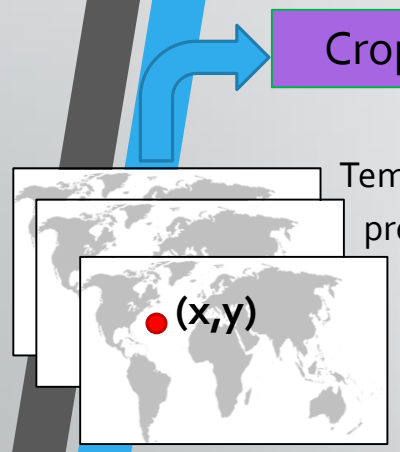
1. Detection and Localization

(2) Model

Stage 1: Data Collection + Labeling

Stage 2: Detection

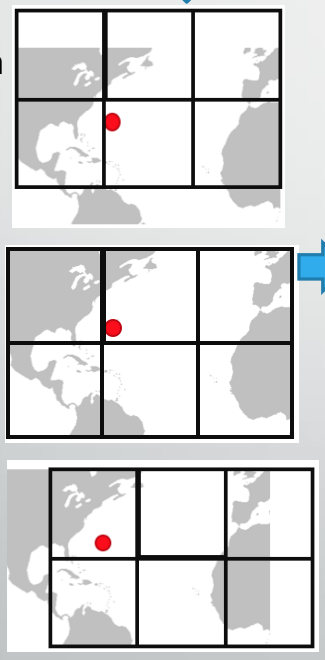
Stage 3: Localization



Temperature
precipitation
:
wind

Climate data
Labeled by historical record

Crop by grids



Hurricane

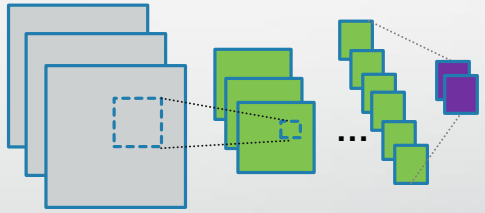
(x'_1, y'_1)

(x'_2, y'_2)

:

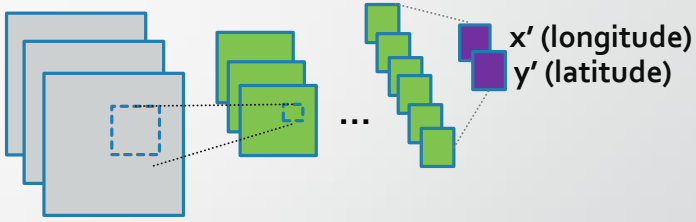
Normal

:

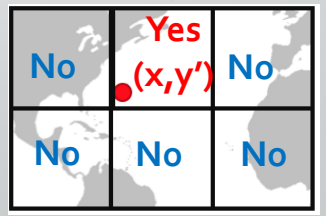


Convolutional Neural Network
Does it contain hurricane?
(Classification)

Yes
No



Convolutional Neural Network
Where is the hurricane?
(Regression)

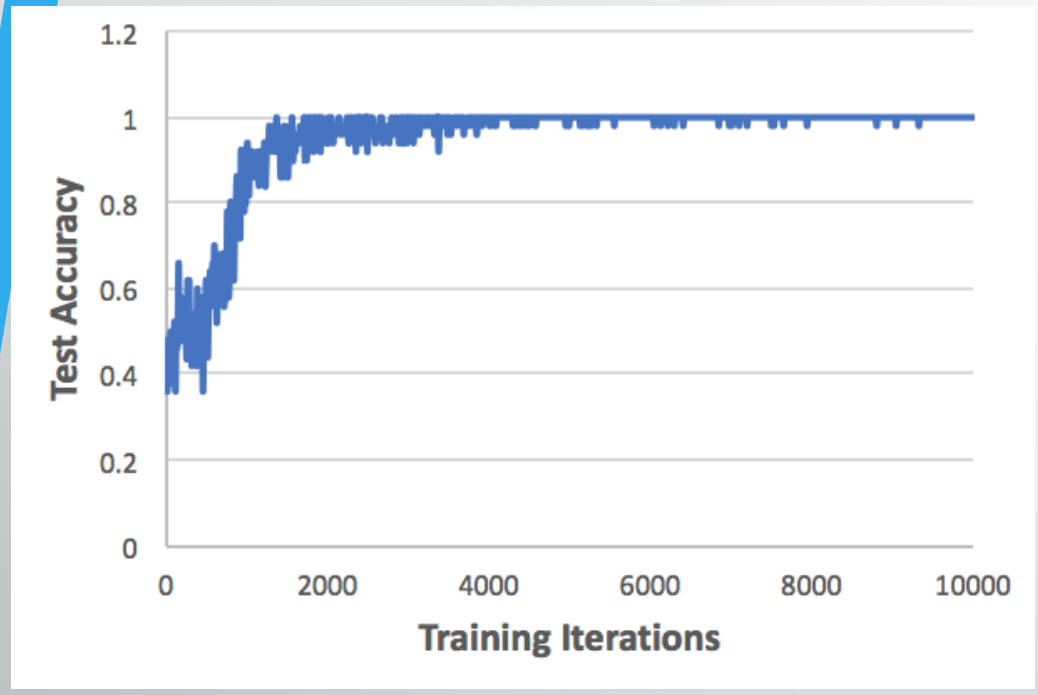


Yes
(x,y)

(1) Detection and Localization

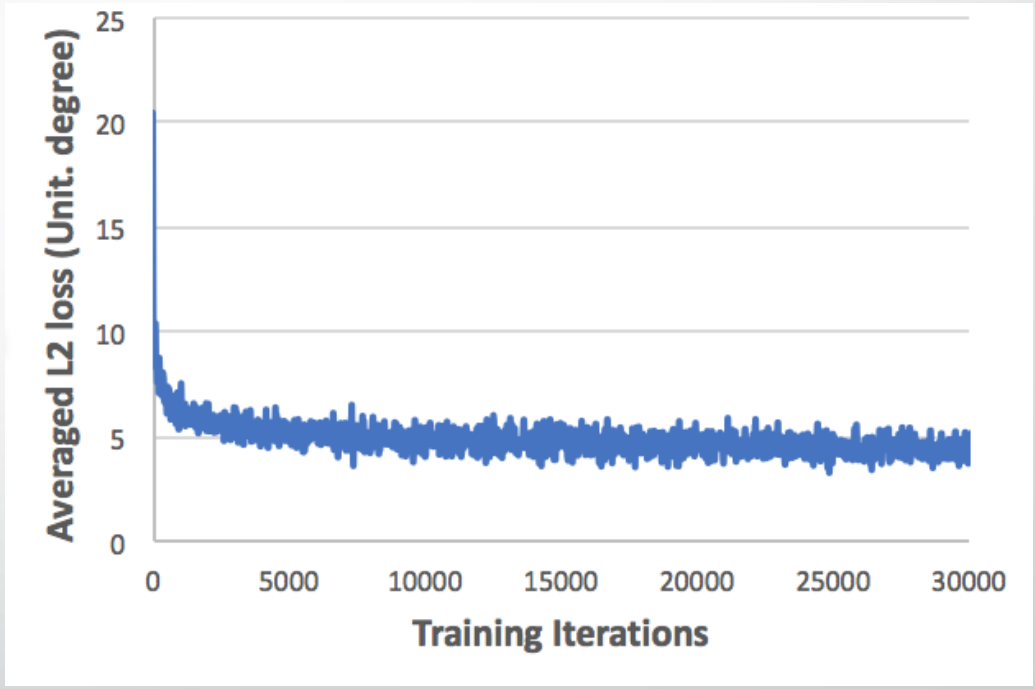
(3) Results

Detection



Almost 100 % test accuracy for detection

Localization

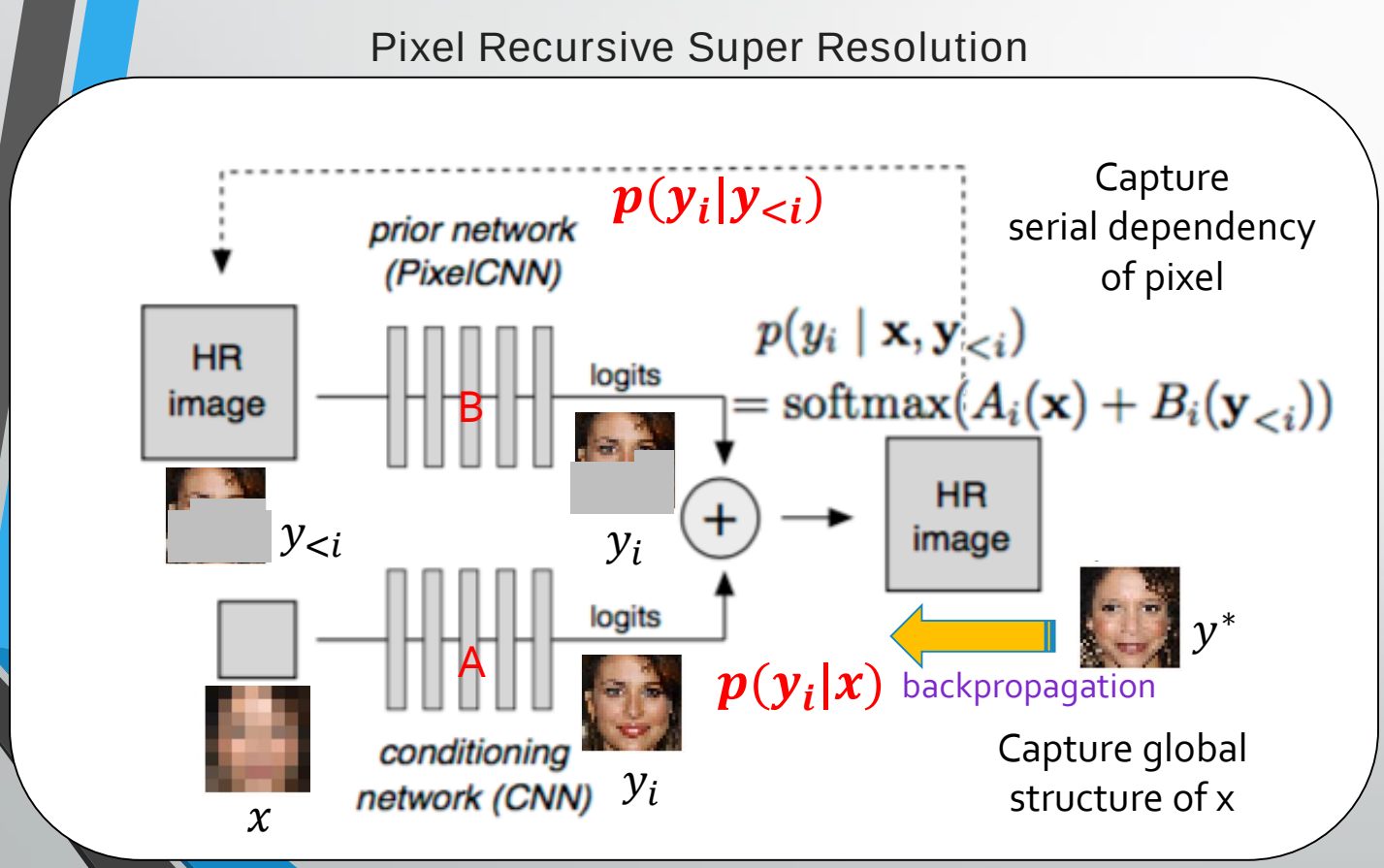


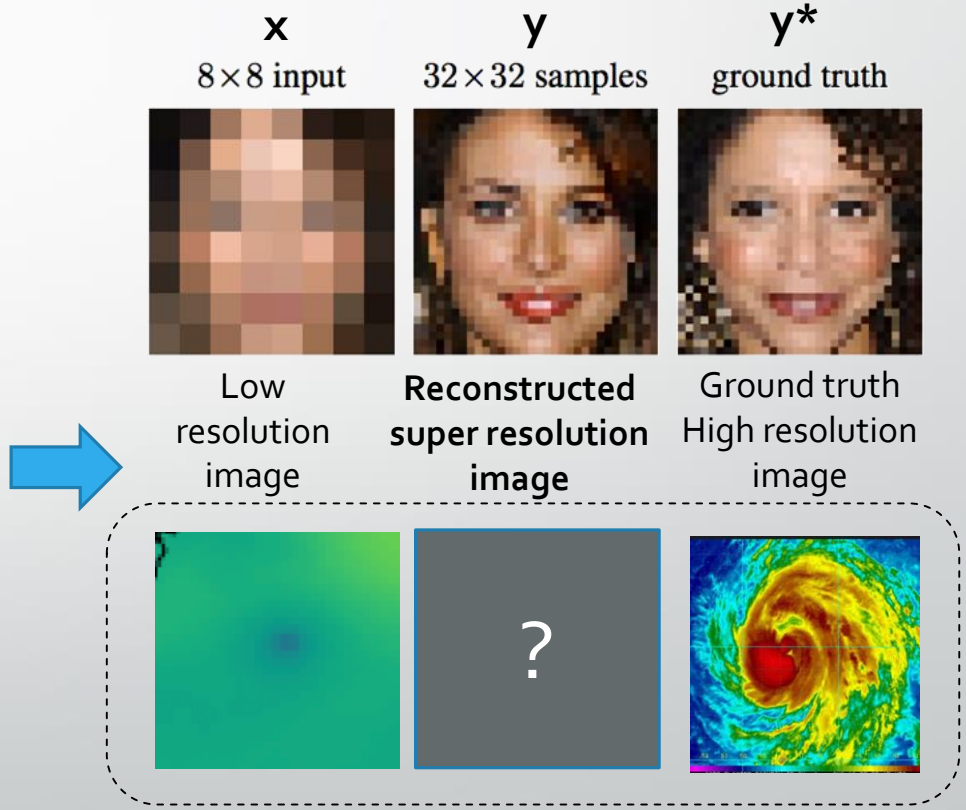
Regression error (L2 loss) is
~ 4 degrees (about 450 km)

Soo Kyung Kim, Sasha Ames, Jiwoo Lee, Chengzhu Zhang, Aaron C.Wilson and Dean Williams " Massive Scale Deep Learning For Detecting Extreme Climate Events"*Climate Informatics* (2017): NCAR/TN536+PROC

(2) Increase localization accuracy using Pixel Recursive Super Resolution

(1) Model

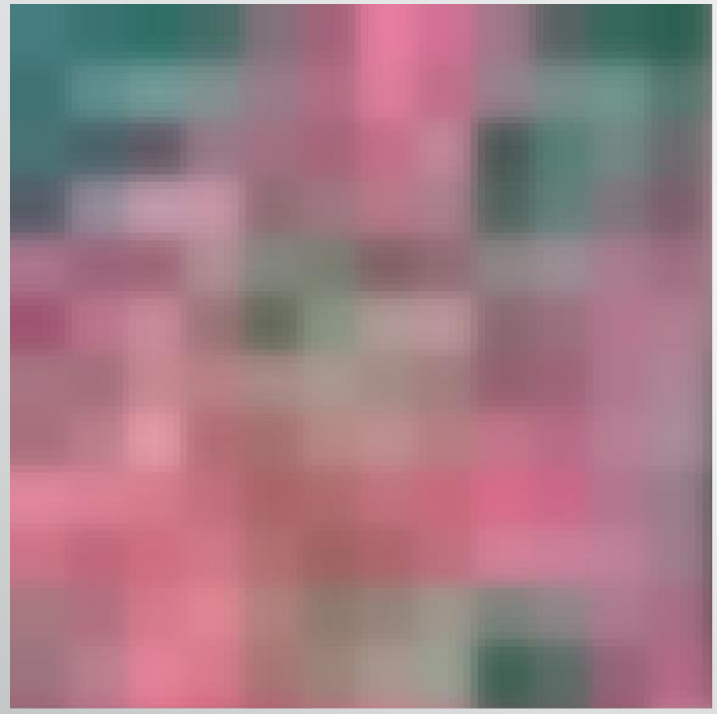




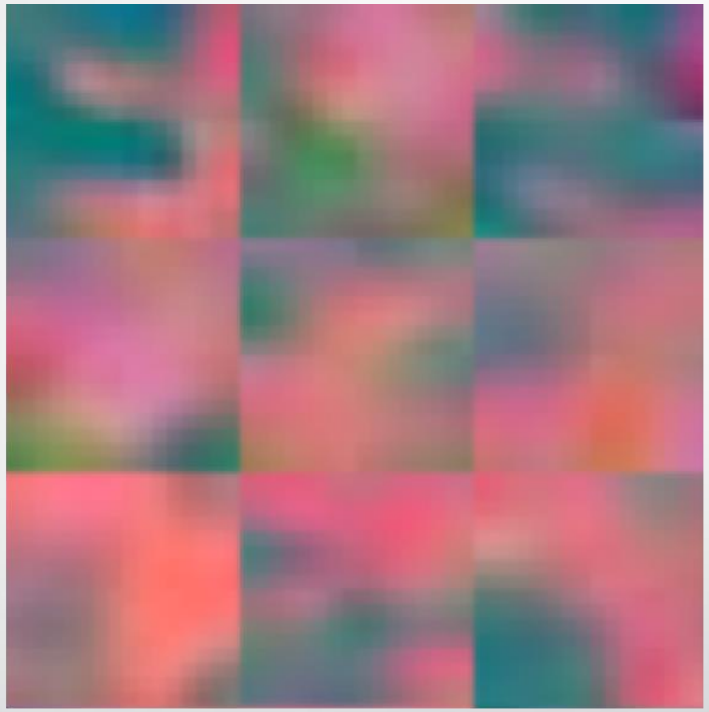
Dahl, Ryan, Mohammad Norouzi, and Jonathon Shlens. "Pixel recursive super resolution." *arXiv preprint arXiv:1702.00783* (2017)

2. Increase localization accuracy using Pixel Recursive Super Resolution

(2) Results



Low Resolution Image



Super Resolution Image (Generated)

High Resolution Image (Ground Truth)

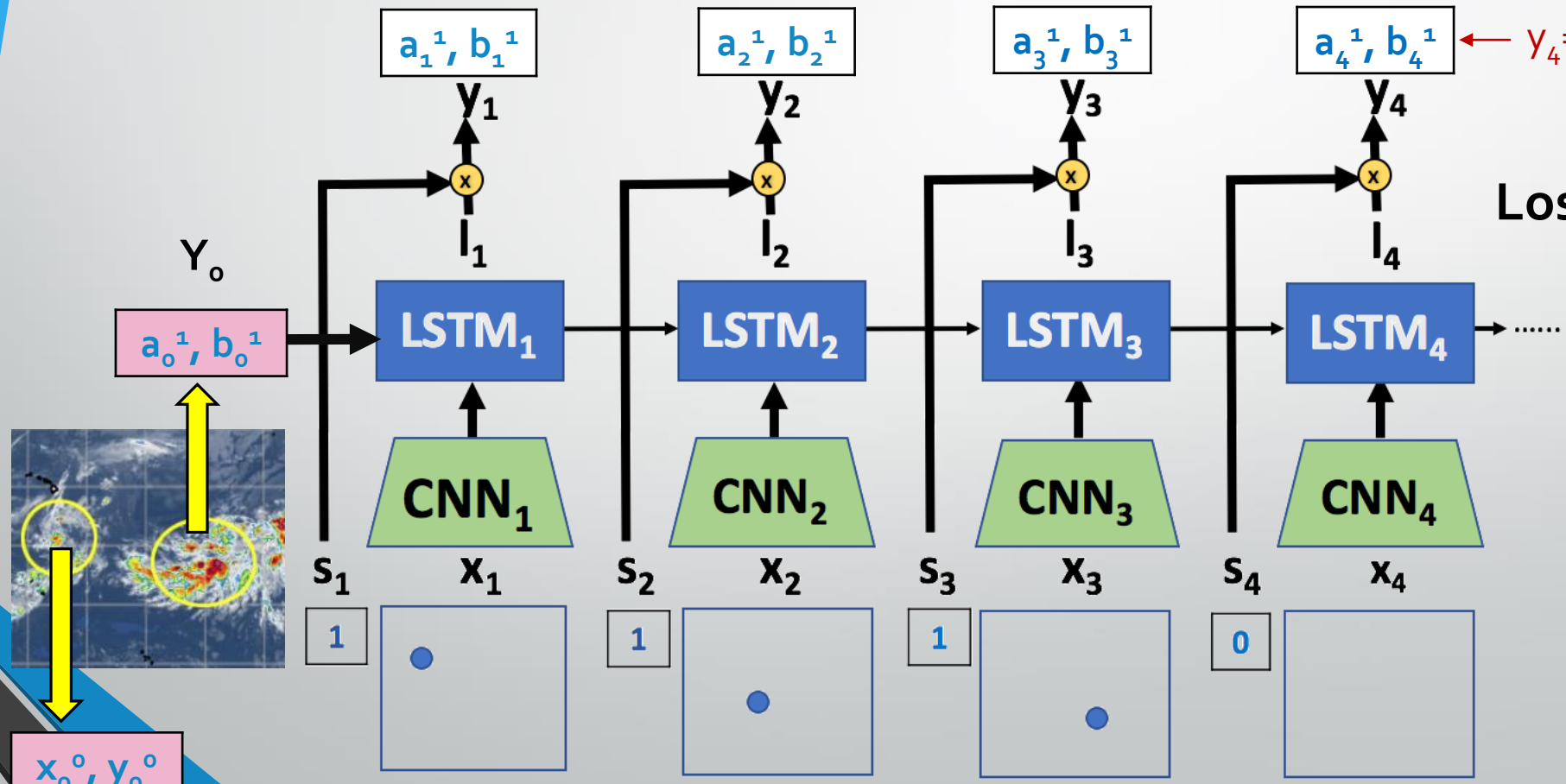
Sookyung Kim, Sasha Ames, Jiwoo Lee, Chengzhu Zhang, Aaron C. Wilson and Dean Williams "Framework for Detection and Localization of Extreme Climate Event with Pixel Recursive Super Resolution." *DMESS, (2017). Seventh Workshop Data Mining on Earth System Science. ICDM on IEEE, 2017.*

3. Tracking Extreme Climate Events

(1) Model

Input : 1. image sequence $X=\{x_1, x_2, x_3, \ldots\ldots x_t\}$,
2. trajectory status sequence $S=\{s_1, s_2, s_3, \ldots\ldots s_t\}$,
3. Initial position Y_0 (i.e: (a_0, b_0))

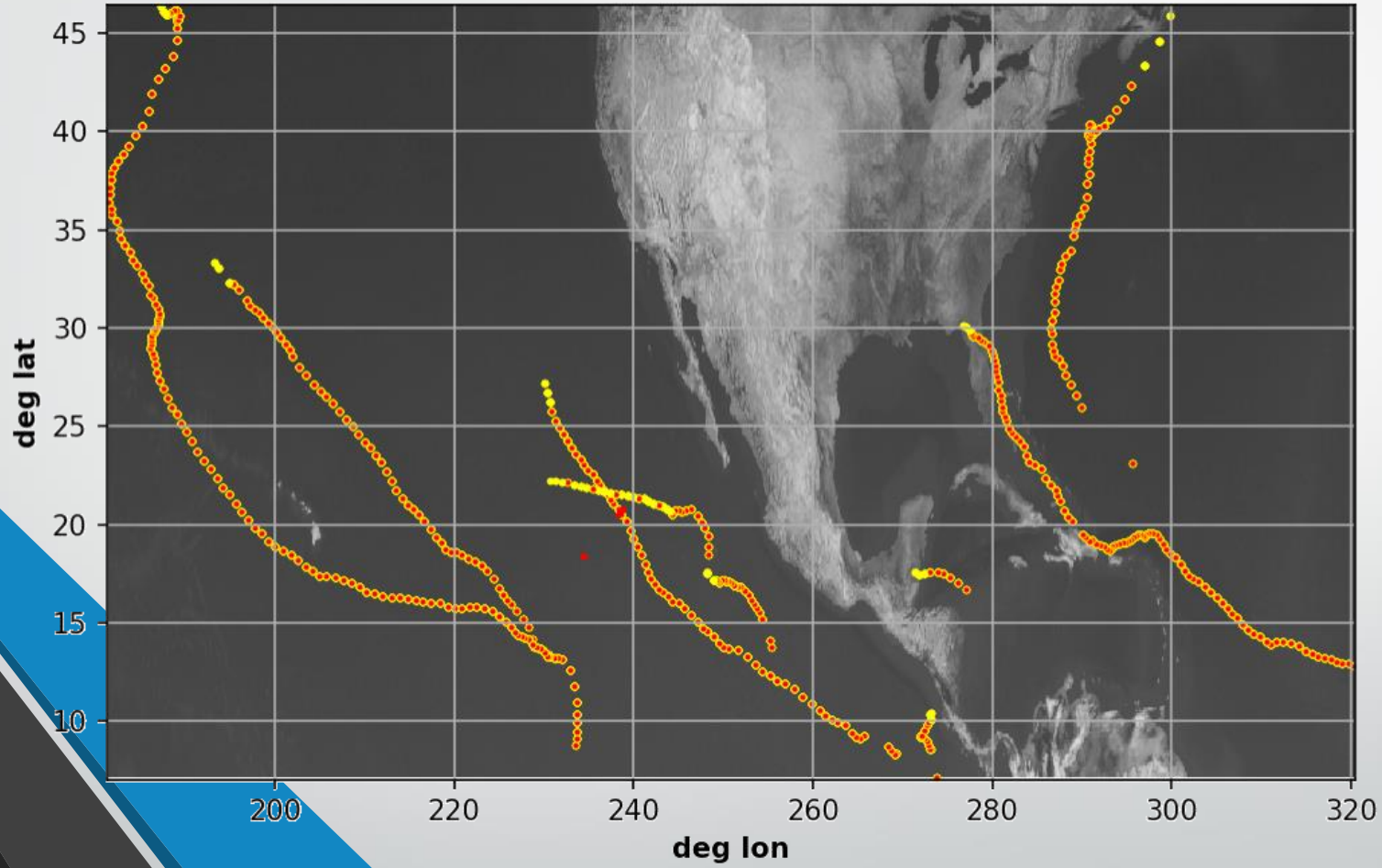
Output: Following trajectory started with Y_0 : $\{y_1, y_2, \ldots. y_t\}$
(i.e: (a_1, b_1), (a_2, b_2), (a_3, b_3)..... (a_t, b_t))



Loss $= mse(\hat{y} - y)$
$= mse(\hat{y} - l * s)$

3. Tracking Extreme Climate Events

(2) Results



Yellow (ground truth), Red (prediction from model)

Mayur Mudigonda, Soo Kim, Ankur Mahesh, Samira Kahou, Karthik Kashinath, Dean Williams, Vincent Michalski, Travis O'Brien and Mr Prabhat "Segmenting and Tracking Extreme Climate Events using Neural Networks" DLPS on NIPS, 2017

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Future Works

- Software Capability
  - Build Machine Learning Infrastructure, API
- Research
  - Deep learning emulator for physical parameterization
  - Time series analysis and prediction: tracking and forecasting climate events, precursor analysis for climate events
- Dataset
  - ClimateNet: Publication of labeled dataset through ESGF
  - Promote deep learning research for Climate Science.

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